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Evaluating the Effect of Different Sand Types on the Physical, Mechanical, and Durability Properties of Sandcrete Blocks in Ghana

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Abstract. The type of sand used in the production of sandcrete blocks greatly influences their strength and durability, which are essential building material qualities in Ghana's construction industry. This study examines how the structural integrity of sandcrete blocks is affected by three different types of sand: pit, river, and sea sand. The mechanical, chemical, and physical characteristics of locally sourced materials were examined in accordance with ASTM guidelines. To create 126 specimens for the experiment, a mixed design with a 1:6, cement-to-fine aggregate ratio and a constant water-to-cement ratio of 0.4 was employed. According to the results, pit sand blocks were the best option for load-bearing structures because they had the highest compressive strength (8.56 N/mm^2) and tensile strength (1.69 N/mm^2), the lowest abrasion resistance (0.62%), and the water absorption rate (8.02%). On the other hand, blocks made of river sand performed moderately well, exhibiting abrasion resistance of 1.46%, tensile strength of 0.92 N/mm2, and compressive strength of 3.26 N/mm^2. However, questions about long-term durability are raised by their higher water absorption rate (13.11%). Sea sand-based blocks were the weakest, with a compressive strength of 2.87 N/mm2, a tensile strength of 0.87 N/mm2, abrasion resistance of 1.97%, and the highest water absorption rate (13.42%), The main cause of this weakness is the high levels of sulphate (4.01%) and chloride (4.57%) in sea sand, which jeopardise structural stability. Significant differences between the three types of sand-based blocks were confirmed by statistical analysis using Tukey's HSD test and one-way ANOVA. These results highlight how important strict quality control is when making sandcrete blocks. To improve construction safety and durability, the study suggests giving river and sea sand priority by properly treating them to improve their qualities. This study contributes to the long-term integrity of buildings in Ghana by highlighting the crucial significance of sand selection and offering insightful advice to legislators and construction experts.

Keywords: Ordinary Portland Cement (OPC), Pit Sand (PS); River Sand (RS); Sea Sand (SS); Sandcrete Blocks

1. Introduction

In Ghana's construction industry, sandcrete blocks play a crucial role in building infrastructure, with over 90% of structures incorporating them as a primary material stated by Baiden & Tuuli (2004) and Anosike & Oyebade (2012). These blocks are widely used for both load-bearing and non-load-bearing walls due to their affordability and ease of production, as noted by Osuji & Egbon (2020) and Wahab & Appiah-Kubi (2024). Made from a mixture of sand, cement, and water, they offer a cost-effective and adaptable solution for various building designs (Andohful et al., 2021). However, concerns remain regarding their strength and durability, which are largely influenced by the quality and type of sand used in their production.

Recent research has highlighted issues with the compressive strength of sandcrete blocks, with many failing to meet standard requirements due to poor-quality sand (Coffie et al., 2019). The type and composition of sand significantly impact the mechanical properties of these blocks, making quality control a critical factor cited by Akorli, Aigbavboa & Ametepey (2023) and Shittu (2023). Studies indicate that many sandcrete blocks produced in Ghana do not meet the Ghana Building Code's required compressive strength of 2.8 N/mm^2, with some testing as low as 1.943 N/mm^2 (Andohful et al., 2021). This shortfall is largely attributed to variations in sand composition, including high levels of silt and clay, which compromise the blocks' structural integrity. Additionally, inconsistent quality control in manufacturing has led to frequent structural weaknesses, increasing the risk of building collapses (Coffie, Adzivor, & Afetorgbor, 2019).

A study by Lumor et al. (2021) compared the performance of sandcrete blocks with those made from quarry dust and found that sandcrete blocks had higher average compressive strength (4.31 N/mm^2) compared to quarry dust blocks (3.0 N/mm^2). Similarly, Alejo (2020) examined sand from different locations in Nigeria and found significant variations in block strength, with Emure sand producing the strongest blocks (5.48 N/mm^2) and Shagari sand resulting in weaker ones (3.56 N/mm^2). Factors such as grain size, silt content, and mineral composition play a crucial role in the strength and durability of sandcrete blocks (Shittu, 2023). Fine sand with high silt content tends et to weaken the blocks, while coarser sand improves strength but can affect workability. Although the Ghana Standards Authority provides guidelines, substandard materials remain common due to cost constraints and weak regulatory enforcement (Andohful al., 2021). Although sandcrete blocks are extensively used in both residential and commercial buildings, there is limited research on how the source of sand affects their long-term performance. This gap raises concerns about structural reliability, construction costs, and environmental sustainability. Addressing these issues through further research can provide valuable data to improve construction practices and inform policy decisions in Ghana's building industry.

2. Materials and Methods

2.1. Materials

Cement, water, sea sand (SS), river sand (RS), and pit sand (PS) were the materials used in this investigation. As per ASTM C33/C33M (2011), the pit sand depicted in Fig. 1(a) was obtained from a renowned sand-winning location in Ekumfi Adansi, which is situated in the Ekumfi District of Ghana's Central Region. In the same way, river sand (Fig. 1(b)) that complies with ASTM C33/C33M (2011) was gathered from the banks of the River Okye in Ekumfi Ekotsi, which is in the same district.

Additionally, sea sand, shown in Fig. 1 (c), meeting the same ASTM standard, was obtained from the coastal community of Ekumfi Arkra in the Ekumfi District. Sandcrete blocks were made using. Portland cement that complied with ASTM C150/C150M (2012). The cement was brought to the lab after being bought from a store in Tanoso, Kumasi. For the mixing process, water from the Ghana Water Company that complies with ASTM C1602/C1602M (2006) specifications was utilised.

Fig. 1. Pit sand (a), River sand (b), Sea sand (c).

2.2 Methods

Three sources of sand were used for the experiment, and their physical, elemental, and oxide compositions were analysed. As seen in Figure 2 (a), the materials were manually combined. A carefully considered mixed design with a 1:6, cement-to-fine aggregate ratio that offers an efficient material blend was used for this experiment. A total of 126 specimens were created by keeping the water-to-cement ratio constant at 0.4. This design approach provided a strong basis for examining the study's final properties and results. As seen in Figure 2(b), the specimens were mechanically moulded using a compressed hydraulic brick-molding machine with a mould size of 100 mm × 100 mm × 100 mm. The mould was oiled to make it easier to remove and to give the specimens a smooth surface. As shown in Figure 2 (c), the mixture was poured into the mould in three layers and compacted with a wooden rammer to remove any voids. The surface of the mould was then levelled and extra material was removed using a metal float. To evenly compress the mixture and create the required specimens, the top cover of the mould was firmly tightened, and the hydraulic jack of the moulding machine was used to apply a pressure of 160 bars. Following moulding, the samples were cured in the lab for 7, 14, 21, and 28 days using the water spraying technique. In compliance with ASTM C90 (2009), the specimens' density, water absorption, compressive strength, tensile strength and wear resistance were assessed after the curing times following ASTM C496/C496M (2004) and ASTM C944 (2019) respectively. Finally, a one-way ANOVA and Tukey's HSD test analysis were performed on the specimens to identify statistically significant differences between the PS, RS, and SS-based specimens.

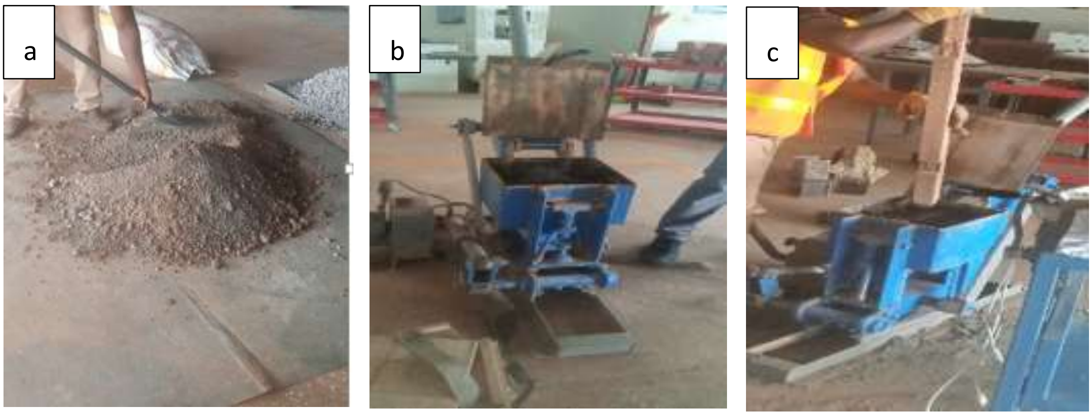

Figure 2. Mixing (a), Mould (b), Compacting (c).

3. Results and discussion

3.1. Results of element and oxide composition of the PS, RS and SS

The element and oxide composition of the PS, RS, and SS is displayed in Table 1, along with the corresponding simulated X-ray diffraction (XRD) pattern based on that oxide composition is displaced in Figure 3. The graph highlights the dominant mineral phases by plotting diffraction intensity against 2θ angles. The following were the main findings drawn from the data: PS (Red, Dashed Line) – Quartz-Dominant With clear peaks at distinctive quartz diffraction angles, the diffraction pattern verifies a high quartz content. SS (Blue, Solid Line) – High Calcite Content: The high $CaCO_3$ levels create strong calcite peaks, but quartz is still present. RS (Green, Dotted Line) – Quartz and Calcite Mix: Consists of both quartz and calcite, producing pronounced calcite peaks.

Additionally, regarding the appropriateness and composition of the material, PS (Quartz-Dominant): PS is highly siliceous, as evidenced by its high quartz content (80.2%) and low $CaCO_3$ (1.4%). Because of its composition, it works well in applications involving high-strength cement. PS is perfect for wear-resistant applications like high-performance applications because of its higher quartz content, which improves abrasion resistance (much like RS and SS). However, it has limited cementing properties due to its low carbonate content. Once more, RS (Quartz & Calcite Mix): Because RS contains both quartz and calcite (5.5% CaCO3), it can be used as a filler in building materials or in applications involving cement of moderate strength.

SS (High Quartz & Calcite): Along with a notable chloride (4.57%) and sulphate (4.01%) content, this sample has an 8.51% $CaCO_3$ content. Because of the possibility of chemical reactions that result in degradation, these extra compounds in SS may jeopardise durability in structural applications. The material is softer due to the high calcite content, which could lessen its mechanical strength. Additionally, the presence of chlorides (Cl^-) and sulphates (SO_4^{2-}) raises the risk of corrosion, rendering SS unsuitable for construction unless properly treated.

Table 1. Results of chemical and oxide composition of the PS, RS and SS.

Properties	PS	RS	SS
pH	5.02%	6.51	8.31
MgO	0.57%	0.37%	1.26%
SiO	80.20%	86.10%	85.50%
Fe_2O_3	2.01%	1.30%	1.52%
Al_2O_3	3.59%	1.59%	2.00%
CaO	0.61%	1.41%	2.51%
K_2O	1.45%	1.51%	2.01%
Na_2O	1.60%	2.00%	3.10%
TiO_2	1.21%	1.09%	-
Cl	-	-	4.57%
SO_4^{2-}	-	-	4.01%
$CaCO_3$	1.40%	5.5%	8.51%

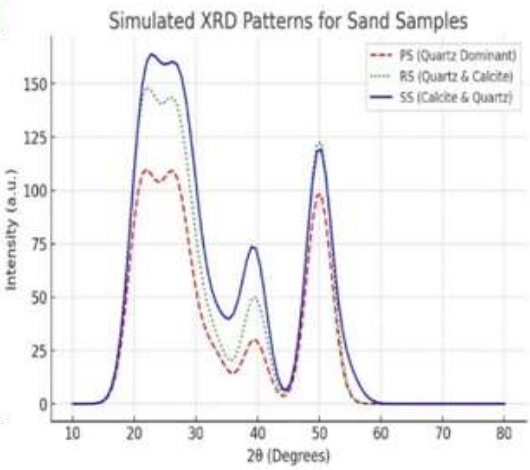

Fig 3. XRD for PS, RS and SS

3.2. Results of physical properties of the PS, RS and SS

Table 2 presents the results of the physical properties of Pit Sand (PS), River Sand (RS), and Sea Sand (SS). PS is sourced from pits, RS is found along riverbanks, and SS is extracted from coastal areas. The geographical origins of these sands significantly influence their physical characteristics. The colour test shows that PS is reddish, indicating the presence of iron oxides. In contrast, RS is light brown, which typically suggests minimal impurities. SS has a light grey colour, possibly due to the presence of salt and organic impurities. In the grain shape test, PS is characterized by coarse, sharp, and angular grains, making it well-suited for binding in cement-based materials. RS features fine to medium-rounded grains, which can result in reduced interlocking strength. SS, with its fine, smooth, and rounded grains, may also diminish mechanical bonding.

Moisture content analysis reveals that PS has the lowest moisture content at 2.57%, indicating it absorbs less water during mixing. RS has a moderate moisture content of 4.0%, while SS has the highest moisture content at 9.35%, which can adversely affect the water-cement ratio in concrete. Additionally, PS has the highest bulk density at 1,900 kg/m^3, resulting in a denser and stronger mix. RS has the lowest bulk density at 1,731 kg/m^3, making it lighter and less compact. SS has an intermediate bulk density of 1,801 kg/m^3, but its salt contamination may render it unsuitable for use without treatment. Furthermore, PS has the highest specific gravity at 2.78, indicating a heavier and stronger material, whereas RS has a moderate specific gravity of 2.60. SS has the lowest specific gravity at 2.51, suggesting it is less dense and potentially structurally weaker.

The implications of these properties for construction applications highlight the suitability of PS for concrete work, thanks to its coarse and angular grains that provide excellent interlocking. Its lower moisture content reduces water demand in the mix, while its higher bulk density and specific gravity contribute to strength and durability. However, the presence of iron oxides may necessitate careful selection to prevent corrosion in reinforced concrete. Conversely, RS, with its finer and rounded grains, has reduced bonding strength and is better suited for plastering rather than structural applications. Its moderate moisture content must be accounted for in the mix design, and its lower density could lead to less durable structures. For SS, the high moisture and salt content can cause corrosion in steel reinforcement, making SS unsuitable for structural applications unless it undergoes desalination treatment. Its fine and smooth texture also reduces mechanical bonding. If properly washed to remove salt, SS can be utilized in non-structural applications or as a secondary aggregate.

Table 2. Results of physical properties of the PS, RS and SS.

Properties	PS	RS	SS
Source	Found in pits	Found in river banks	Found in coastal areas
Colour	Reddish	Light brown	Light gray
Grain size	Coarse, Sharp, Angular	Fine medium, rounded	Fine smooth, rounded
Moisture content	2.57 %	4.0 %	9.35 %
bulk density	1,900 kg/m^3	1,731 kg/m^3	1,801 kg/m^3
specific gravity	2.78	2.60	2.51

3.3. Results of particles size grading analysis of the PS, RS and SS

The particle grading analysis results for PS, RS, and SS used in this experiment are shown in Figure 4. According to the study, PS had a sand content of 98.30%, a gravel content of 1.70%, and no silt or clay. In a similar vein, SS recorded 80.11% sand, 19.89% gravel, and 0% silt and clay, whereas RS had 89.73% sand, 10.27% gravel, and 0% silt and clay (Figure 3). Interestingly, there was no discernible silt or clay content in any of the fine aggregates. According to the findings, PS, which has the most sand, is well-graded and probably will provide good workability for the production of sandcrete blocks, which will increase their strength and durability. Pit sand and other well-graded sand typically improve compressive strength and compaction. On the other hand, RS and

SS have coarser particles, which could impact bonding, increase porosity, and reduce cohesiveness in sandcrete. In comparison to pit sand, this might result in a minor decrease in overall strength. Poorly graded sand produces porous and weak blocks, according to research (Alejo, 2020). Although it is not taken into account in the grading analysis, the study also raises the possibility that sodium chloride (NaCl), a significant durability concern, may be present in SS. According to the grading analysis, PS seems to be the most appropriate for creating long-lasting blocks among PS, RS, and SS for the Ghanaian construction industry. Although RS and SS are still usable, additional processing might be necessary to improve their bonding and fineness.

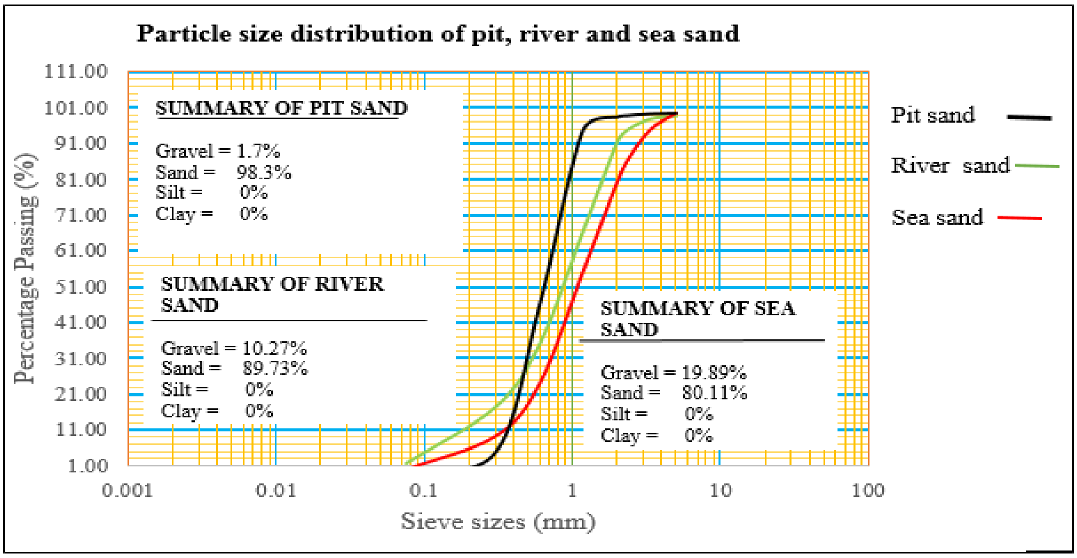

Fig 4. Results of particles size grading curve for PS, RS and SS.

3.4. Results of density test of the specimens

The air-dry density results for the PS, RS, and SS-based blocks for 7, 14, 21, and 28 curing days are displayed in Figure 5, respectively. According to the results, PS-based sandcrete blocks have the highest air-dry density (2,422.92 kg/m^3). In comparison to blocks made of RS or SS, this implies that PS-based blocks are denser and more compact, which could result in higher compressive strength and longer durability. Blocks based on RS and SS, on the other hand, have lower densities; initial measurements for RS and SS were roughly 2,117.38 kg/m^3 and 2,132.63 kg/m^3, respectively. Density values are constantly lower than those of PS-based blocks, despite variations over time.

From day 7 to day 28, the density of all types of sand gradually decreases, most likely as a result of water loss during the curing process. The blocks lose some mass as the moisture evaporates, but their internal bonding structure keeps getting stronger. Because the well-graded particles found in the grading analysis of PS enhance workability during the production of PS-based sandcrete blocks, PS-based blocks have a higher density. Better compaction and improved performance are typically the results of using well-graded sand, like PS. However, because of their higher gravel content, RS and SS-based blocks have coarser particles. In comparison to PS-based blocks, this results in slightly lower densities by affecting bonding, increasing porosity, and decreasing cohesion within the sandcrete mix.

The findings imply that density and compressive strength are strongly correlated. PS-based blocks are probably stronger and better suited for load-bearing structures like walls and columns because of their higher density. RS and SS-based blocks, on the other hand, maybe less strong due to their lower densities, which makes them better suited for non-load-bearing applications like partition walls. Furthermore, PS-based blocks are anticipated to provide superior resistance to weathering and structural failure, making them a better option in areas that frequently experience high humidity or heavy rainfall. Particularly vulnerable to sulphate and chloride degradation were SS-based blocks, underscoring the necessity of comprehensive desalination before use.

In conclusion, even though PS-based blocks perform better, the high demand for raw materials (PS) means that their environmental impact needs to be carefully managed. In the meantime, to improve their qualities and general performance, RS and SS-based blocks might need to be treated, treated with additives, or have their mix designs optimised.

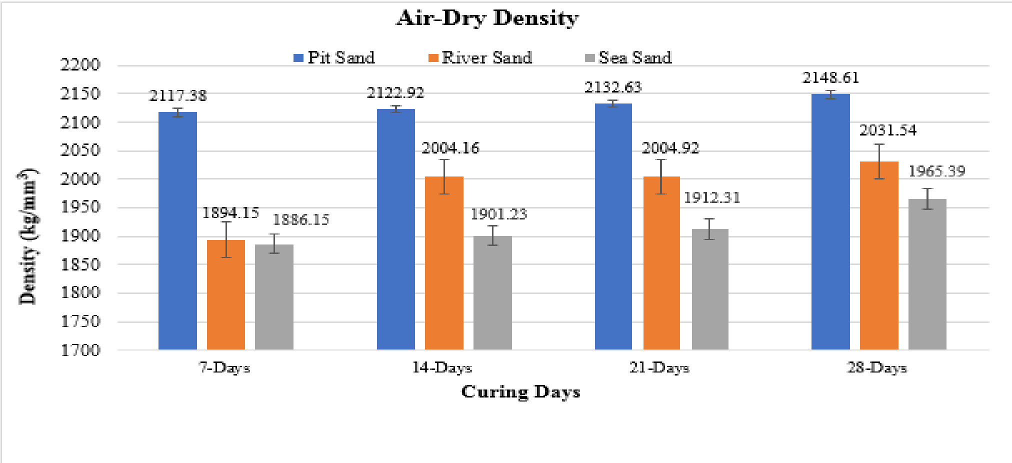

Fig 5. Results of the air-dry density of the PS, RS and SS-based blocks.

3.5. Results of water absorption test of the specimens

Following 28 days of curing, Figure 6 (a) displays the specimens immersed in water, and Figure 6 (b) displays the water absorption test results for blocks made from PS-based blocks, RS-based blocks, and SS-based blocks, respectively. The graph gives important information about the performance of the three sand-type-based blocks by highlighting differences in absorption rates. Water absorption rates were found to be 8.02% for PS-based blocks, 13.11% for RS-based blocks, and 13.42% for SS-based blocks in the study. These findings show that SS-based blocks have the highest absorption, which is marginally higher than that of RS-based blocks, while PS-based blocks have the lowest absorption rate, followed by RS-based blocks. PS's angular grains are well-known for improving its cement-bonding properties. If PS-based blocks may have fewer or no pores, they have lower water absorption, as indicated by the graph which may also translate into greater strength and durability.

With angular grains of the PS enhancing cement bonding and decreasing porosity, this result implies that PS is well-graded. PS-based blocks consequently absorb less water and are less vulnerable to problems caused by moisture. The rounded grains in RS, on the other hand, contribute to a moderate absorption rate even though it is also well-graded. A balance between workability and durability is indicated by the mid-range absorption seen in RS-based blocks. Nonetheless, SS's high sulphate (4.01%) and chloride (4.57%) contents might led to SS-based blocks absorbing more water. This raises the possibility of degradation over time and raises the possibility of durability issues brought on by excessive moisture retention. The durability of sandcrete blocks under various environmental circumstances is greatly influenced by their ability to absorb water. Greater porosity, which can result in decreased compressive strength and quicker deterioration, is indicated by high absorption rates. This is especially important in areas that experience a lot of rainfall or high humidity, as water infiltration can gradually erode structures. Blocks composed of extremely absorbent materials, like sea sand, might deteriorate more quickly, requiring more upkeep and costing more to fix.

Because PS-based blocks, with their low water absorption exceptional retention rates, are more appropriate for load-bearing walls and structural applications. For general construction, where durability is crucial but extreme strength is not needed, those with moderate absorption rates, usually made from river sand, are suitable. On the other hand, if salt contamination is adequately managed, blocks with high absorption rates, which are frequently formed from the sea, might be better suited for temporary construction or non-load-bearing applications. If sea sand is to be used, it must be properly cleaned and treated to lower or eliminate the salt content, which will lower the levels of absorption. Similarly, to improve durability, changes to the mix design, such as adding waterproofing admixtures, may be required if river or sea sand shows high porosity.

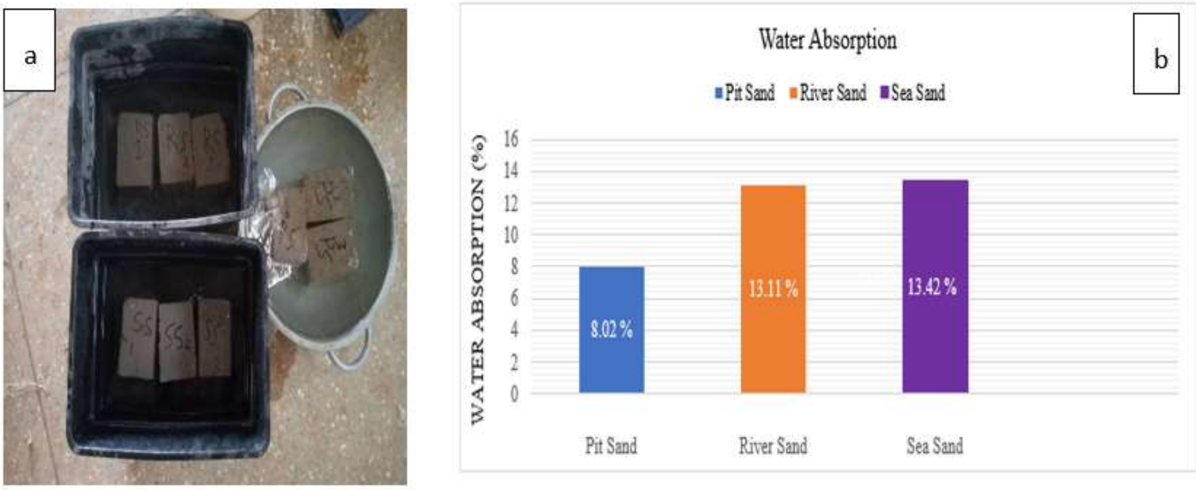

Fig 6. Results of water absorption test of the specimens.

3.6. Results of Tukey's HSD test on the water absorption of the specimens

The findings of Tukey's HSD test, which was used to compare the water absorption of the three sand-based block types, are shown in Table 3. According to the analysis, there is a statistically significant mean difference in water absorption between PS and RS blocks of 5.09%. This suggests that compared to PS blocks, RS blocks absorb noticeably more water. Likewise, the statistically significant mean difference between PS and SS blocks is 5.4%, indicating that SS blocks absorb significantly more water than PS blocks. The water absorption characteristics of the two block types are comparable, however, as the mean difference between RS and SS blocks is only 0.31% and not statistically significant. According to these results, PS blocks are the most ideal option for building projects where reducing water retention is crucial because they have the lowest rate of water absorption. On the other hand, RS and SS blocks exhibit comparable water absorption properties, which permits their interchangeability in applications when properly treated.

Table 3. Results of Tukey's HSD test on the water absorption of the specimens.

Comparison	Mean Diff.	Std error	P- Value	95 % Conf. Inter.	significant
PS vs RS blocks	5.09	0.5	<0.05	**significant**	Yes
PS vs SS blocks	5.40	0.5	<0.05	**significant**	Yes
RS vs SS blocks	0.31	0.5	>0.05	**Not significant**	No

3.7. Results of compressive strength test of the specimens

The compressive strength test and results for PS-based blocks, RS-based blocks, and SS-based blocks are shown in Figures 7 (a) and (b), respectively. Figure 7 (b) shows that the compressive strength of sandcrete blocks generally increases with curing time across all sand-type-based blocks. Strength measurements at 7, 14, 21, and 28 days show a progressive increase, with PS-based blocks achieving the highest compressive strength of 8.560 N/mm^2 at 28 days. This strength gain represents an increase of 5.30 N/mm^2 over RS-based blocks and 5.69 N/mm^2 over SS-based blocks; this is probably due to the superior bonding properties in the PS-based blocks matrix.

The compressive strength of RS and SS-based blocks differed by 0.39 N/mm^2. PS-based blocks continuously show greater strength in overall curing times, and RS-based blocks outperform SS-based blocks with a comparable upward trend. The presence of salts, which can erode the bond between cement and aggregates, may be the cause of the SS-based blocks' relatively lower strength. These results imply that pit sand improves workability, compaction, and overall strength in the production of sandcrete blocks due to its well-graded composition and higher sand content. Well-graded sand produces better compaction, which greatly increases durability and compressive strength.

The superior compressive strength of PS-based blocks at 28 days indicates that sandcrete blocks made with pit sand are suitable for load-bearing walls in residential and commercial buildings. In contrast, blocks made with river and sea sand may require treatment, such as additives buildings and desalination, to enhance their structural integrity. Research has shown that sand type significantly impacts the compressive strength of sandcrete blocks (Baiden & Tuuli, 2004).

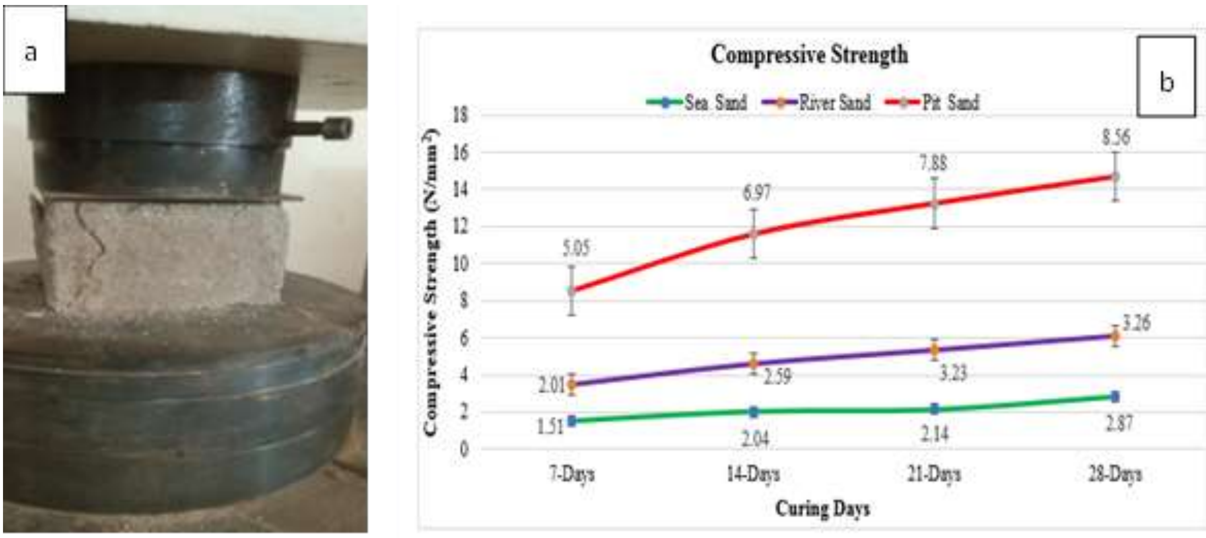

Fig 7. Results of compressive strength test of the specimens.

3.8. Results of one-way ANOVA test on the compressive strength of the specimens

Table 4 presents the results of a one-way ANOVA test comparing the compressive strength of block samples made with different types of sand after 28 days of curing. The findings shows that blocks made with pit sand had the highest mean compressive strength at 8.560 MPa, followed by those made with river sand at 3.260 MPa, while sea sand blocks had the lowest strength at 2.867 MPa. The Holm-Sidak test for statistical significance further revealed key differences between these groups: Pit sand-based vs. Sea sand-based block: Significant difference (p = 0.003). Pit sand blocks vs. river sand blocks: Significant difference (p = 0.003) and river sand blocks vs. sea sand blocks: No significant difference (p = 0.590). These results suggest that PS-based blocks are the most suitable choice for structural applications due to its superior compressive strength. Blocks made from PS are ideal for load-bearing structures such as beams, columns, and foundations. On the other hand, SS-based blocks are unsuitable for structural use unless properly treated (e.g., desalination), as its very low compressive strength (2.867 MPa) could compromise structural integrity. RS-based blocks serves as a moderate alternative, offering better strength than SS-based blocks (3.260 MPa) but still significantly weaker than PS-based blocks.

Table 4. Results of one-way ANOVA test on the compressive strength of the specimens.

Treatment Name	N	Missing	Mean	Std Dev	SEM
Pit sand	3	0	8.560	0.630	0.364
River sand	3	0	3.260	0.615	0.355
Sea sand	3	0	2.867	1.313	0.758

All Pairwise Multiple Comparison Procedures (Holm-Sidak method)

Comparison	*Diff of Means*	*T*	*P*	*P<0.050*
Pit Sand vs. Sea Sand	5.693	8.459	0.003	Yes
Pit Sand vs. River Sand	5.300	7.875	0.003	Yes
River Sand vs. Sea Sand	0.393	0.584	0.590	No

3.9. Results of tensile strength test of the specimens

Figure 8 (a) presents the split tensile strength test, Figure 8 (b) presents the failure mode of the specimen, and Figure 8 (c) presents the results of the split tensile strength test for specimens cured for 7, 14, 21, and 28 days. Figure 8 (d) illustrates the stress-strain curves of the materials under tensile load. As shown in Figure 8 (c), the tensile strength of all specimens increased with curing time, reflecting continuous hydration and strength development. For blocks made with PS, the tensile strength rose from 1.10 N/m^2 at 7 days to 1.33 N/m^2 at 14 days, 1.39 N/m^2 at 21 days, and 1.69 N/m^2 at 28 days. At all curing ages, PS-based blocks exhibited the highest tensile strength, followed by those made with RS and then SS.

The lower strength observed in SS-based blocks may be due to the presence of salts, which can interfere with cement hydration. The slightly better performance of RS-based blocks compared to SS-based blocks could be attributed to better gradation and cleanliness. These findings suggest that PS-based blocks are the most suitable for applications requiring high tensile strength due to their superior performance. In contrast, SS-based blocks should be used cautiously in critical applications because of their comparatively lower strength.

To further analyse the material behaviour under stress, the stress-strain curves shown in Figure 8 (d) were examined. The curves reveal an upward trend in tensile strength with increasing strain, indicating that all materials gain strength gradually over time. PS-based blocks consistently recorded the highest stress values at all strain levels, confirming their superior tensile performance. RS-based blocks exhibited slightly lower tensile strength but followed a similar trend. In contrast, SS-based blocks displayed the lowest stress values, suggesting weaker bonding, likely due to salt content. The stress-strain relationship further reinforces that PS-based blocks are the most suitable for high-tensile applications, while RS and SS-based blocks may require treatment to improve their strength characteristics. The shape of the curves indicates a typical brittle failure pattern, which is characteristic of cement-based materials.

Fig 8 (a). Split tensile strength test, (b). Failure mode of the specimen.

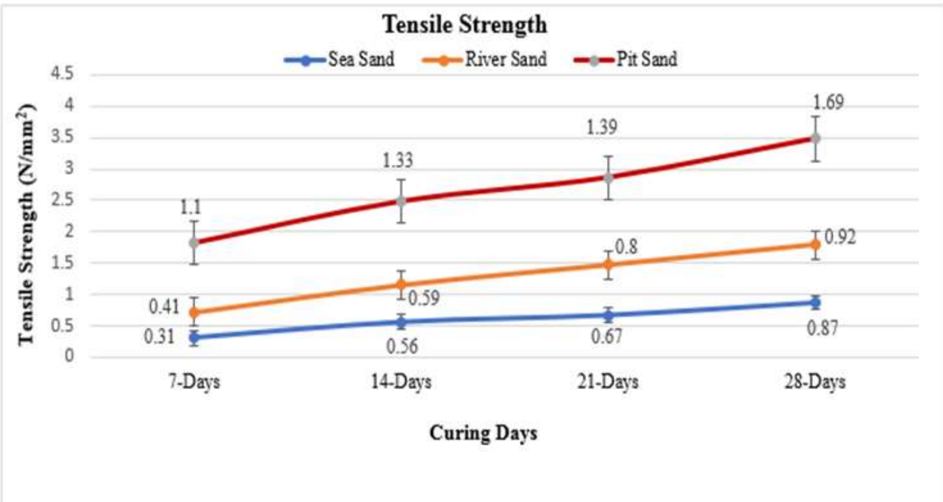

Fig 8 (c). Results of split tensile strength test for specimens.

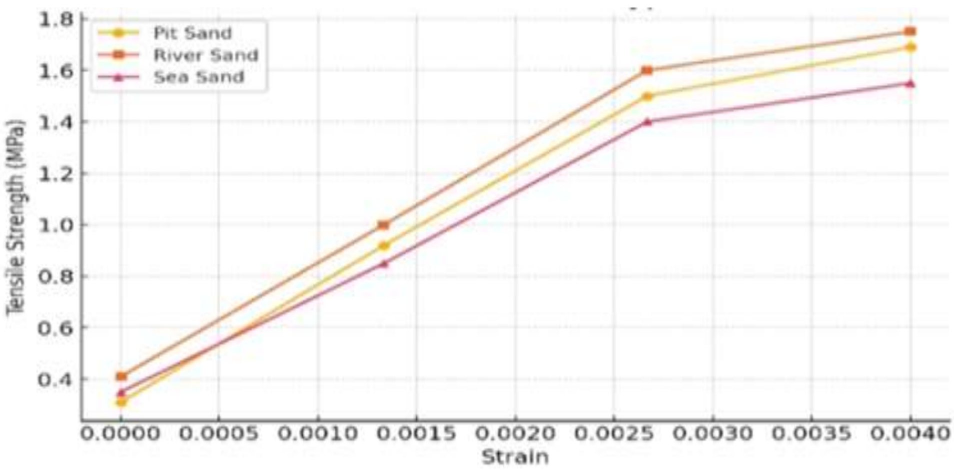

Fig 8 (d). Stress-Strain curves.

3.10. Results of abrasion resistance test of the specimens

Figure 9 shows the results of the abrasion resistance test conducted on specimens after 28 days of curing. Figure 10 also illustrates a 3D model visual representation for the rate of wear under abrasion. The study revealed that specimens made with river sand and sea sand exhibited greater abrasion wear compared to those made with pit sand. Specifically, the abrasion resistance of the pit sand-based blocks was measured at 0.62%, which was 0.84% and 1.34% lower than that of the river sand and sea sand-based blocks, respectively.

Pit sand is typically rough and angular, which can enhance strength and abrasion resistance by improving particle interlocking. If the surface wear on pit sand-based blocks is minimal as shown in Figure 10 (a), it suggests that the angular grains contribute to better resistance against abrasion. In contrast, river sand is smoother and has more rounded particles, which can reduce the overall strength of sandcrete blocks. Significant wear on river sand-based blocks shown in Figure 10 (b) may indicate that fine particles compromise cohesion, leading to weaker interparticle bonding and led to increased wear. Similarly, sea sand was found to contain high chloride (4.57%) and sulfate (4.01%) content that weaken cement bonding and accelerate material degradation. Higher wear levels, as observed in Figure 10 (c) in sea sand-based blocks, may be attributed to high chloride (4.57%) and sulfate (4.01%) content affecting hydration and reducing overall durability under mechanical stress.

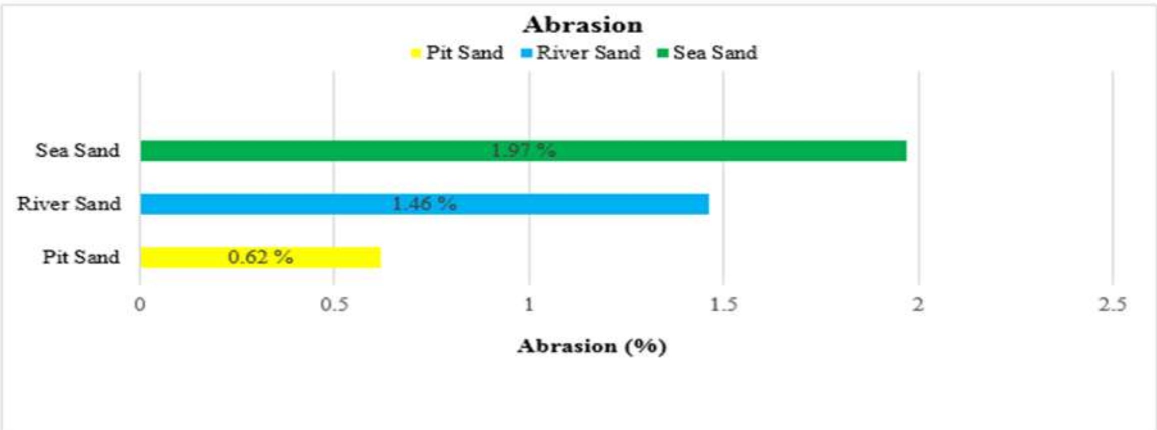

Fig 9. Results of the abrasion resistance test.

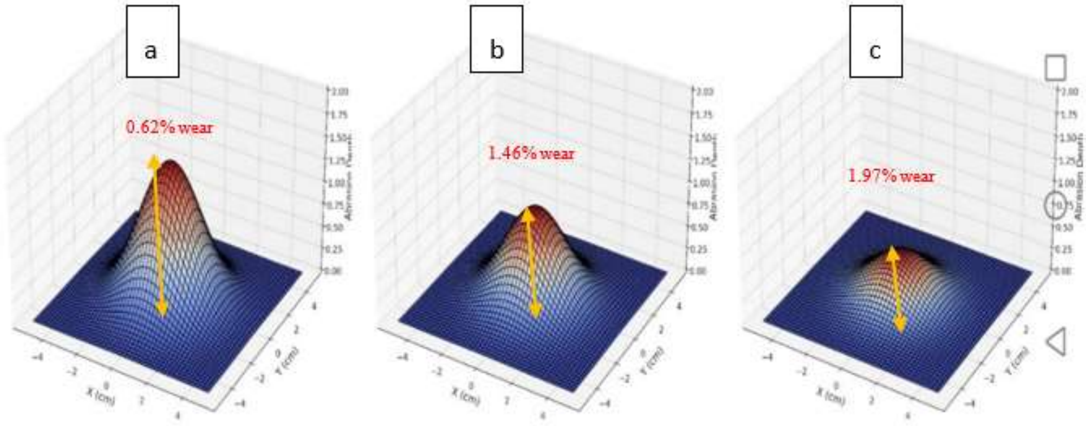

Fig 10. (a) PS- Lowest abrasion wear, (b) RS- Moderate abrasion wear, (a) SS- Highest abrasion wear.

4. Conclusions

This study shows that the strength, durability, and water absorption of sandcrete blocks is significantly influenced by the type of sand used. Pit sand was the best choice out of the three sand types tested because of its high quartz content, superior compaction, and low porosity, which produced blocks that were stronger and more resilient. Although river sand performs moderately, its high water absorption raises questions about its long-term durability. Sea sand is easily accessible, but if it isn't properly treated before use, its high levels of sulphate (4.01%) and chloride (4.57%) compromise structural integrity. In terms of compressive strength, tensile strength, water absorption, and abrasion resistance, blocks made with pit sand performed noticeably better than those made with river and sea sand, according to statistical analysis. These results demonstrate how urgently Ghana's construction sector needs stronger quality control procedures to stop the use of inferior materials that could jeopardise building safety. This study provides crucial suggestions for raising construction standards and material selection because sandcrete blocks are widely used in both residential and commercial construction. Future studies utilising PS, RS, and SS from various regions should be investigated, as should strategies to improve the performance of sea and river sand for construction applications, such as desalination and mixing with high-strength additives. The construction sector in Ghana can produce longer-lasting, safer, and more sustainable structures by implementing these strategies.

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